



Technical Rescue

Rope Rescue Operator Course

Student Notes

Introduction to Rope Rescue

The aim of this section of the manual is to detail standard methods of working and rope rescue techniques. This will provide the information necessary to achieve Technical Rescue Rope Operator standard as approved by DFRS.

This section of the Technical Rescue Manual is designed to enable operators to: -

- Demonstrate competence in ascending and descending ropes.
- Perform a full range of rope manoeuvres.
- Select and secure anchor points at various locations.
- Tie a range of knots appropriate to special rescue.
- Demonstrate competence in the inspection and maintenance of equipment.
- Perform all rope rescue techniques to a high standard of safety

A TECHNICAL RESCUE OPERATOR SHOULD ONLY CARRY OUT A RESCUE IN THE PRESENCE OF, AND UNDER THE SUPERVISION OF A TECHNICAL RESCUE SUPERVISOR/INSTRUCTOR.

This manual is designed to accompany the Technical Rescue Operators Course, during the acquisition stage of training. This manual is also to be used for consolidation training in the application stage and for continuation training in the management of competence. Some of the content of this document has been directly taken from the Fire and Rescue Service Manual, Volume 2, Fire Service Operations – Safe Work at Height and Outreach training packages.

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Equipment

Petzl I'D - S – (Industrial Descender) - Self Locking Belay Device.



When using this type of belay device it will be necessary to incorporate additional friction into the system when working with loads over 150kg.

For heavy rescue loads up to 200kg the control rope should be clipped into a karabiner. This will give additional friction and control. This karabiner is called a braking karabiner.

For heavy rescue loads in excess of 200kg up to a maximum of 250kg the systems requires more control. This is achieved in two ways, either by taking an extra turn on the control rope that is clipped into the braking karabiner, or by making an Italian hitch on the braking karabiner.

Croll – Rope Clamp



The Croll (rope clamp) used by the Specialist Rescue Teams conforms to EN 567 (Rope Clamps).

Rocker – Rope lock



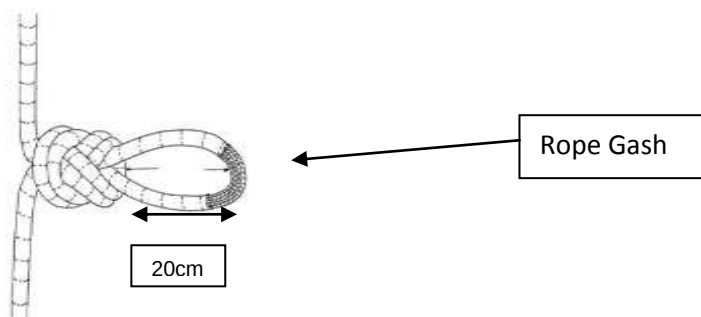
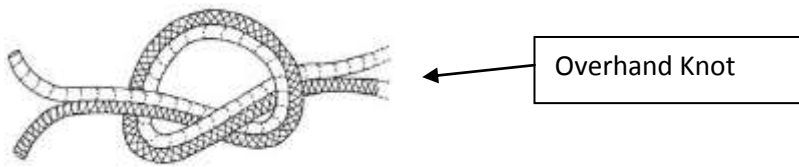
The rope lock used by the Technical Rescue Team is made by ISC and conforms to EN 353-2:1992 (personal protective equipment for prevention of falls from a height-guided type fall arresters) and EN 358:1999 (Personal protective equipment for work positioning and prevention of falls from a height-belts for work positioning and restraint and work positioning lanyards).

Petzl Ascender - Rope Grab



The ascender used by the Technical Rescue Teams is made by Petzl and conforms to EN 567 (Rope Clamps).

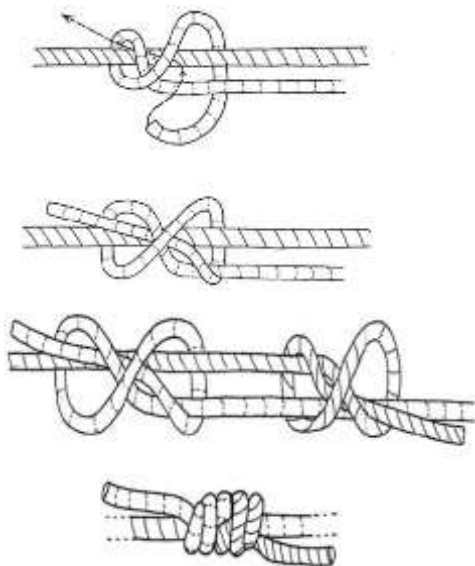
KNOTS



Rope Gash is the term given to the use of an overhand or figure of eight knot when used to isolate an area of damaged rope. The distance between the knot and the damaged area should be at least 20cm

Fisherman's Knot

Double Fisherman's



The Figure of Eight Knot

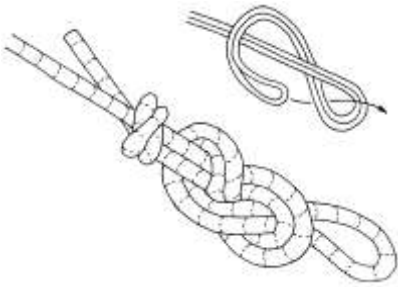
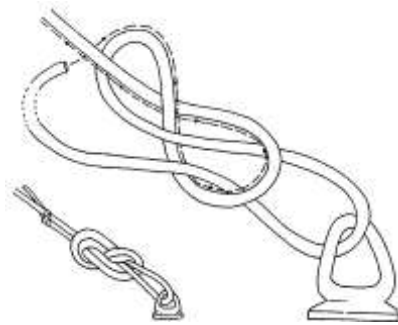
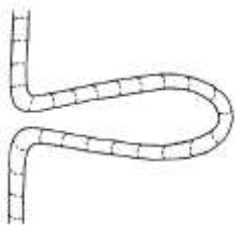


Figure of eight with a stopper knot

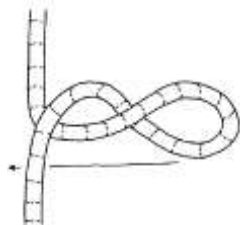


Rewoven figure of eight

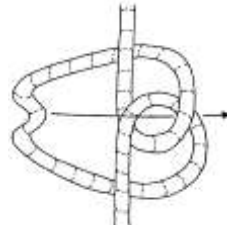
Alpine Butterfly



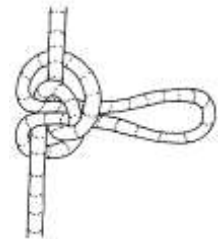
1



2

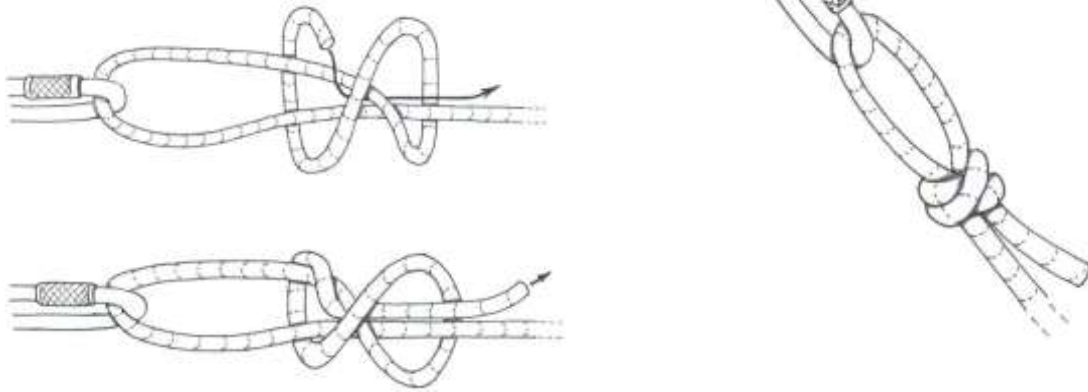


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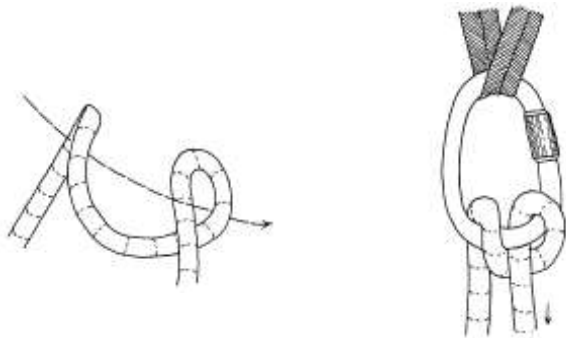


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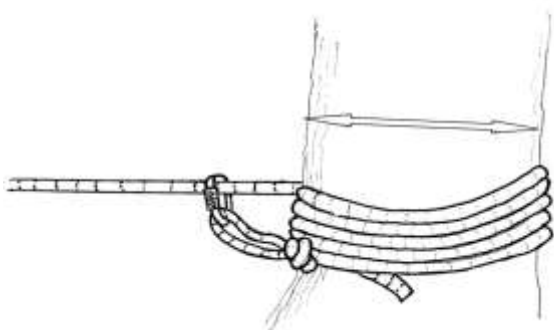
Barrel Knot



Italian Hitch



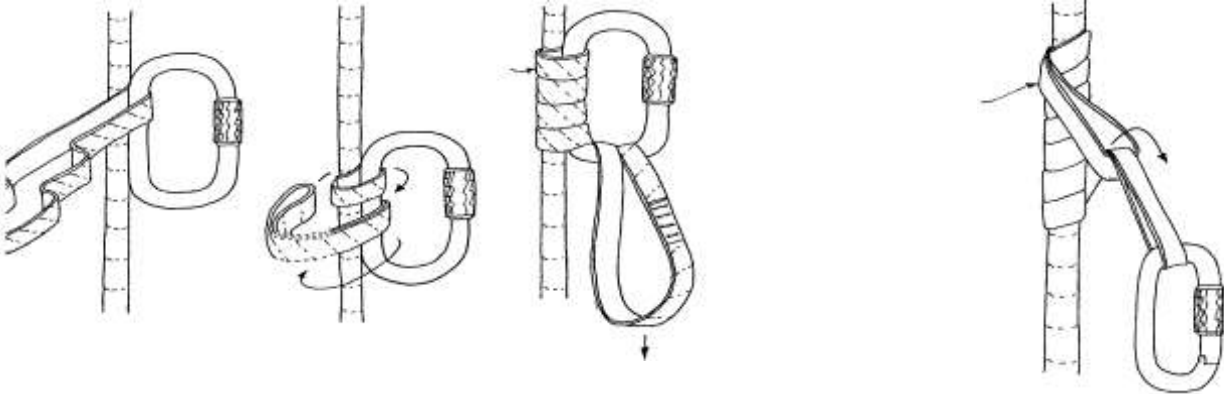
Tensionless Hitch (No Knot)



On an unquestionably sound anchor,
diameter to 4 x the rope diameter with a
minimum of 5 wraps

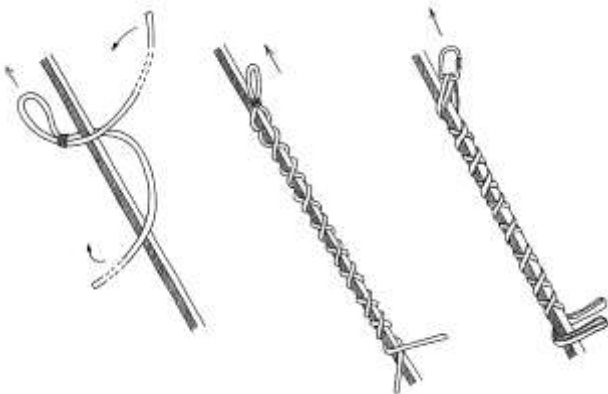
Be wary of trees and their states of health and structural stability.

Friction Knots

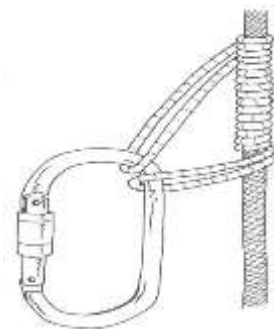


Bachman Knot

Klemheist Knot



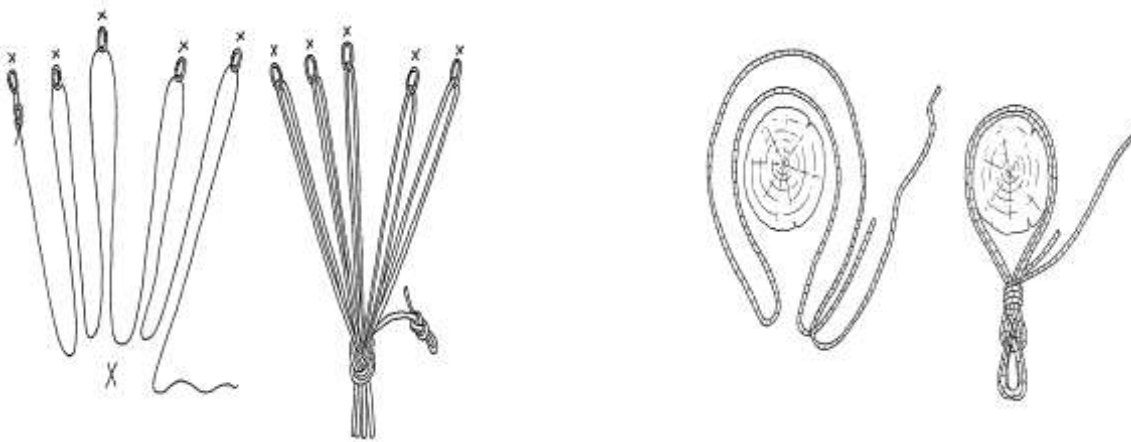
Rope Dog



French Prussic

All the friction knots grip the rope under load, but can be slid when the load is released. Care must be taken using Klemheist knots as they can also be released by personnel whilst loaded

The Big Knot



The big knot is used to create a multi-point anchor, using a rope connected to several points and terminating in a figure of eight, or overhand knot

Rope Types and Dynamics

Although climbing and rescue ropes are usually credited with a breaking strain of around 35500kg, it is important to understand the range of rope types and variety of strains placed upon them by different situations and the relevant dangers.

Two forms of construction are used in modern nylon ropes:

1. **Kernmantle** – these have an inner core of fibre bundles protected by a woven outer sheath
2. **Multi braid** – these are braided bundles of fibres without an outer sheath (not used within DFRS Rope Rescue Team).

Where practicable, working ropes should be red and safety ropes white. It must, however, be accepted that this cannot always apply.

“Pre-stretched” or **“static”** ropes, i.e. Low stretch kernmantle (LSK) ropes designed to be non-elastic. These are useful for situations where a more springy rope would be cumbersome to work with, e.g. abseils, cableways. LSK ropes will stretch approximately 5%. They are not designed to withstand shock loading.

An Introduction to Systems Analysis

Put simply, systems analysis is the process by which we decide whether a particular rope rescue system is safe to use. By conducting a few simple calculations and applying a number of “what if?” questions, we can calculate the strength of the system and its component parts. By this process we can identify the “weakest link in the chain” and can also determine the systems ability to withstand a dynamic event or shock load, as might be caused by equipment failure or operator error.

Item	Typical Breaking Strength (kN)
6 mm LSK Cord (unknotted)	7.5
7 mm LSK cord (unknotted)	10
8 mm LSK cord (unknotted)	12.5 – 15
10 mm LSK (unknotted)	22
11 mm LSK (unknotted)	30 – 33
15 mm Dyneema/Spectra sewn sling	22-25
Steel “D-shaped” karabiners	40
Alloy “D-shaped” karabiners	30
Alloy “HMS” karabiners	25
Alloy ringing plate	40
Swing-cheek pulley	30 - 40

Note that knots in rope, cord and tape can reduce the breaking strength by up to 39% (based on HSE tests). However, for all practical applications and calculations a loss of 33% or a third may be used.

100% Redundancy - Whenever possible it is advisable to build 100% redundancy into a rope system. This means that: -

Any component part within a system is backed up by another.

This doubling up considerably increases the margin of safety. Potential flaws in a system will always be twofold:

- There will always be a possibility of faults within the mechanics of the system.
- There is also the threat of human error, particularly in situations where people are working under pressure and in adverse conditions.

Critical Point Examination:

The critical point examination involves ensuring that all points are backed up by other system components in such a way that no one point (either equipment or personnel) would cause a serious or fatal accident if it were to fail.

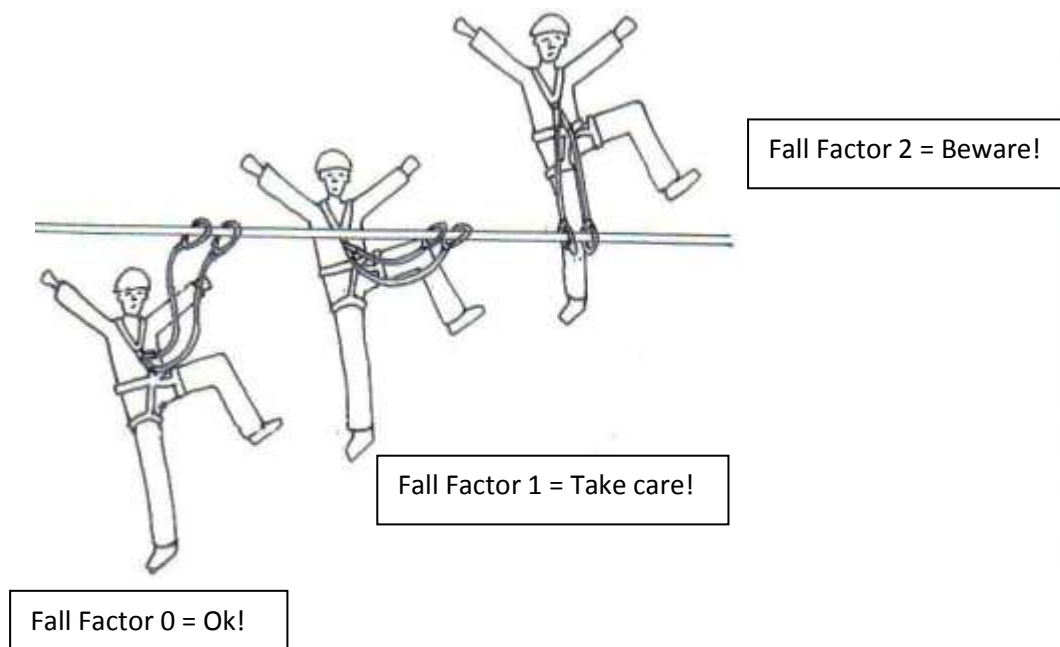
STATIC SYSTEM SAFETY FACTOR (SSSF)

To achieve the desired dynamic safety ratio when building a rope system, we should ensure that the strength of the system and its component parts is at least 10 times greater than the force applied by the static rescue load. By adopting a **static system safety factor** of 10:1 we are ensuring that the materials used in the system are not loaded past their yield point and will survive a limited dynamic event such as might occur during a difficult edge transition from horizontal to vertical. Note however that the application of a 10:1 SSSF is intended as a guideline, not a black and white rule, and it should not be treated as such.

Fall factors

Fall factors are used to identify the potential seriousness of a fall, for the person taking the fall and the equipment and anchors that arrest the fall. It is effectively a ratio between the length of the fall and the length of the rope available to absorb the impact force created by its arrest and is calculated using the following equation:

$$\text{Fall Factor} = \frac{\text{Length of fall}}{\text{Length of rope available}}$$



Fall factor greater than 2 may result in serious injury and/or equipment failure.

Free Space Clearance

A considerable amount of free space below is required if impact with the ground or obstacles is to be avoided following a fall severe enough to fully deploy the lanyard's shock absorber. A distance equivalent to the length of the lanyard *plus* the length of the deployed shock absorber (typically 1m) *plus* the distance between the harness attachment and the wearer's feet (typically 1.5m) *plus* a stopping distance of 1m is required. In the case of 1.5m lanyards, this means that:

Lanyard length + connectors = 1.5 metres

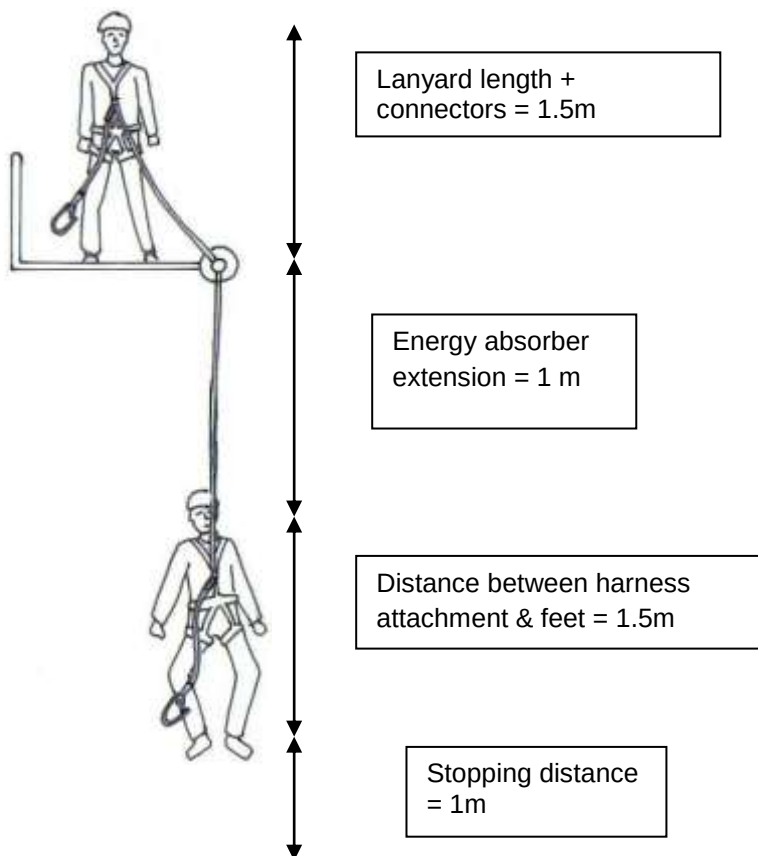
Energy Absorber extension = 1 metre

Distance between harness

Attachment and feet = 1.5 metres

Stopping distance = 1 metre

Clearance distance required = 5 metres



THESE FIGURES ARE FOR GUIDANCE ONLY

PLEASE REFER TO SPECIFIC LANYARD OPERATING INSTRUCTIONS FOR SPECIFICATIONS

15. Edge Management

When working at height, safe practices must be strictly followed to prevent falling. A safe zone should be maintained where all personnel **must** be secured to an anchor point, this is individual protection.

Individual protection can be achieved in one of three ways:

- **Work restraint.**
- **Fall arrest.**
- **Work positioning.**

Work restraint

The objective of work restraint is to restrict an individual's movement so that access to any location where there is a risk of a fall from height is not possible.

The minimum system required to achieve the necessary restriction on travel will be:

- A suitable waist belt or harness.
- A rope or lanyard.
- An effective anchor.

Fall Arrest

Fall arrest systems are designed for use in situations where the risk of a fall likely to cause injury exists.

A suitable fall arrest system will include:

- A fall arrest harness complying with BS EN361.
- An energy absorbing element
- A connecting rope or lanyard
- An effective anchor.

Work Positioning

Work positioning systems will consist of a primary system and a backup system that will come into operation should the primary system fail for any reason.

A work positioning system must include:

- A harness complying with BS EN358.
- An effective anchor.
- A connecting rope and rope control device, or
- A suitable lanyard system.

Use of lanyards for fall arrest, work positioning and work restraint

Note: The following notes apply specifically to the use of lanyards. However, Fall Arrest, Work Positioning and Work Restraint can also be provided by the use of ropes and suitable anchors.

Appropriate lanyards may be used to provide the following:

- **Fall Arrest**

To safely stop a person falling by limiting distance and force of a fall.

Access – egress (up, down, across)

- **Work Positioning**

To support a person while working by means of PPE in tension, so as to prevent a fall

Working at height, either suspended or supported. Normally used in conjunction with fall arrest.

- **Work Restraint**

To prevent a person entering an area from which a fall from height risk exists.

Work adjacent to a drop (e.g. edge person)

Summary

1. I want to –

Work adjacent to an edge but need to be prevented from entering the risk area.

I NEED - a **Work Restraint** System

2. I want to –

Climb up, down or across in a position where a fall resulting in injury could occur.

I NEED- a **Fall Arrest** System

3. I want to -

Work hand-free in a position where a fall resulting in injury could occur.

I NEED- **Work Positioning** in addition to **Fall Arrest**

Rope Manoeuvres

When operating in the rope rescue environment there may be a situation where an operator will need to carry out a self-rescue procedure. It is essential that all team members have the skills to carry out the necessary manoeuvres to remain safe on rope rescue systems.

When ascending or descending a rope, it may be necessary to pass a knot or to change from one set of ropes to another. This is done by the following methods.

Throughout these manoeuvres it should be remembered that **TWO** points of contact should be maintained, as a minimum, at **all** times (100% redundancy). An I'D, a stop, an ASAP and a cow's tail or lanyard may be considered as one point of contact each, however, an Ascender and a Croll count only as a half point of contact each. For example, ASAP + ascender + Croll = 2 points of contact.

Ascending

- Attach ascender and Croll to working rope.
- Attach ASAP to safety rope.
- Begin ascent, ensuring ASAP is kept high at all times.

Descending

- Attach descender to working rope and lock off.
- Attach ASAP to safety rope.
- Unlock descender and begin descent, ensuring ASAP is kept high at all times.

Ascending Past a Knot

- The ascender must be as close to the knot as possible.
- Attach a point of contact to the working rope.
- Place the ascender above the knot.
- Place the Croll above the knot.
- Unclip the cow's tail and continue ascent.
- **Throughout the manoeuvre ensure the ASAP is kept at head height.**

Descending Past a Knot

- Descend to a position slightly above the knot (approximately 10-15 cm)
- Fit the ascending gear to the rope above the knot.
- Ascend the rope to a point where all the weight is just taken by the ascending gear.
- Remove the descender and refit it below the knot ensuring to lock it off.
- It may then be necessary to use the ascending gear to descend to the point just above the knot, if the distance is too great to comfortably change from ascent to descent.
- If it is necessary to descend, the Croll **MUST NOT** be removed from the rope whilst descending.
- Careful placing of the ascender is now necessary, to allow the Croll to be removed and the weight to be taken by the descender. Place the ascender as close as possible to the Croll whilst still being able to remove it.
- Remove the Croll from the rope and allow the weight to be taken on the descender.
- It should now be possible to remove the ascender, as all the weight should be on the descender only.
- Continue descent.
- **Throughout the manoeuvre ensure the ASAP is kept at head height.**

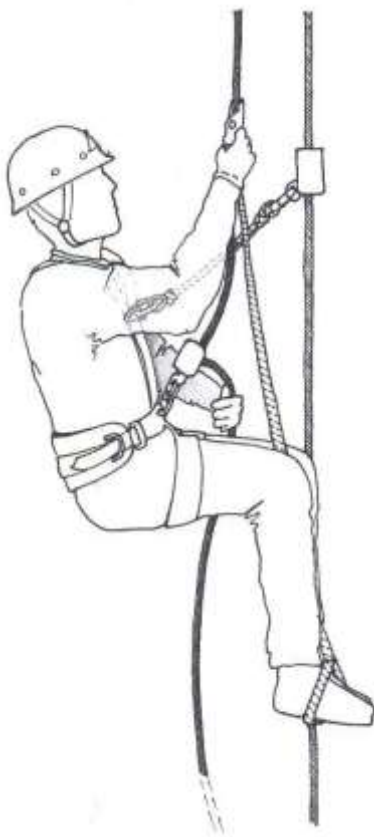
Transfer From One Set of Ropes to Another

On Descent

1. Lock off descender.
2. Fit ascending gear onto new working rope.
3. Fit ASAP onto new safety rope.
4. Unlock descender and descend until weight is on ascending gear. Remove descender and fit to new working rope.
5. Lock off descender and remove ascending gear.
6. Unlock descender and continue descent.
7. **Throughout the manoeuvre ensure the ASAP is kept at head height.**

On Ascent

1. Tie knot in safety rope and attach cow's tail or suitable lanyard.
2. Remove ASAP and attach to new safety rope.
3. Remove ascender and place onto new working rope.
4. Remove Croll and place onto new working rope.
5. Remove cow's tail from old safety rope and untie knot.
6. Continue ascent



Window Cleaner Rescue

The 'window cleaner' or 'snatch' rescue is the simplest method of carrying out the rescue of a person who is wearing a harness.

Although individual supervisors can select the best method to deal with a situation, the following must be adhered to;

- Belay and descending devices for use within Window cleaner rescues must be two person rated i.e. an I'D.
- The casualty must be provided with a separate safety line that must be top lowered also using a two person rated belay device.
- The Quick draw must be connected to the waist attachment of the rescuers harness.

Window cleaner rescue

The rescuer should always be equipped with a means of cutting ropes.

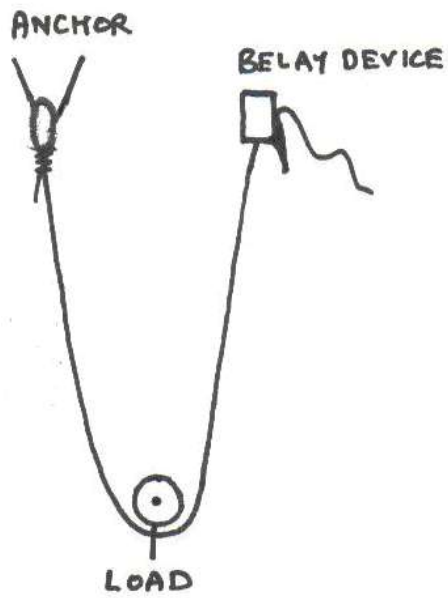
- Rescuer should descend to a position slightly above the casualty; connect the casualty safety rope to the sternal or dorsal attachment of the casualty's harness. (If there is one)
- Rescuer should then get into a position to connect the Quickdraw to the waist attachment point of the casualty's harness. When in position the rescuer should lock off their descender.
- With their descender locked off the rescuer can connect the Quickdraw to the casualty.
- With the casualty now on the rescuers system the rescuer will now need to clip the control rope through a braking karabiner.
- The rescuer can now lower the casualty onto their system. Using the casualty's descender or if this is not possible they can cut the casualty's ropes to release them from their rigging.
- Once the casualty is on the rescuer's system the rescuer can descend with the casualty to safety.

Pulley Systems

Pulley systems allow heavy loads to be moved by applying a proportionately lower effort over a longer distance. This ratio of load to effort is known as the Mechanical Advantage (MA) of a pulley system.

- When constructing a pulley system for hauling a rescue load (i.e. 2 persons or more), you will find that by employing only 4 single swing-cheek pulleys it is possible to build a simple 5:1 system. Use of single pulleys then allows us to rapidly and easily “change gear” either up or down to provide either a 3:1 or a 9:1 mechanical advantage (MA), with no additional equipment, providing rescuers with 3 options that will deal with most haul situations. It is of course possible to “piggy-back” this pulley system on to a 2:1 “V-rig”, which will provide MAs of 2:1 (V-rig alone), 6:1 (V-rig + 3:1), 10:1 (V-rig + 5:1) or 18:1 (V-rig + 9:1).
- For short hauls, a V-rig with a further simple pulley system built on as required is an excellent solution. Use of this configuration is however limited by the length of rope available i.e. the haul rope must be *at least* twice as long as the distance that the load is to be moved. See diagrams.
- Where practicable, it is generally most efficient to build pulley systems directly out of the end of the Main line, using an I“D or other suitable rope control device as an autobloc/ratchet, to allow the system to be re-set as required.
- Wherever possible, always use best quality pulleys when constructing a pulley system. At best, pulleys are 95% efficient, compared to a karabiner, which is only 60% efficient when used as an improvised pulley. This loss in efficiency will significantly reduce the *Actual Mechanical Advantage* of the system against the *Ideal Mechanical Advantage*.
- Operate any pulley system as smoothly as possible to avoid giving the casualty & guide a jerky ride and to avoid placing excessive forces on the anchor system. Avoid using a “heave-ho” action; instead, either walk (slowly) with the haul rope or use a hand-over-hand motion. Be prepared, if necessary, to „change gear“ to a higher mechanical advantage, to allow smoother hauling.

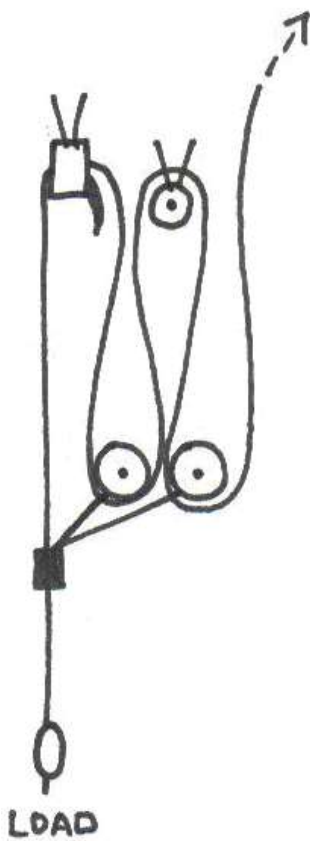
V - Rig



3:1



5:1



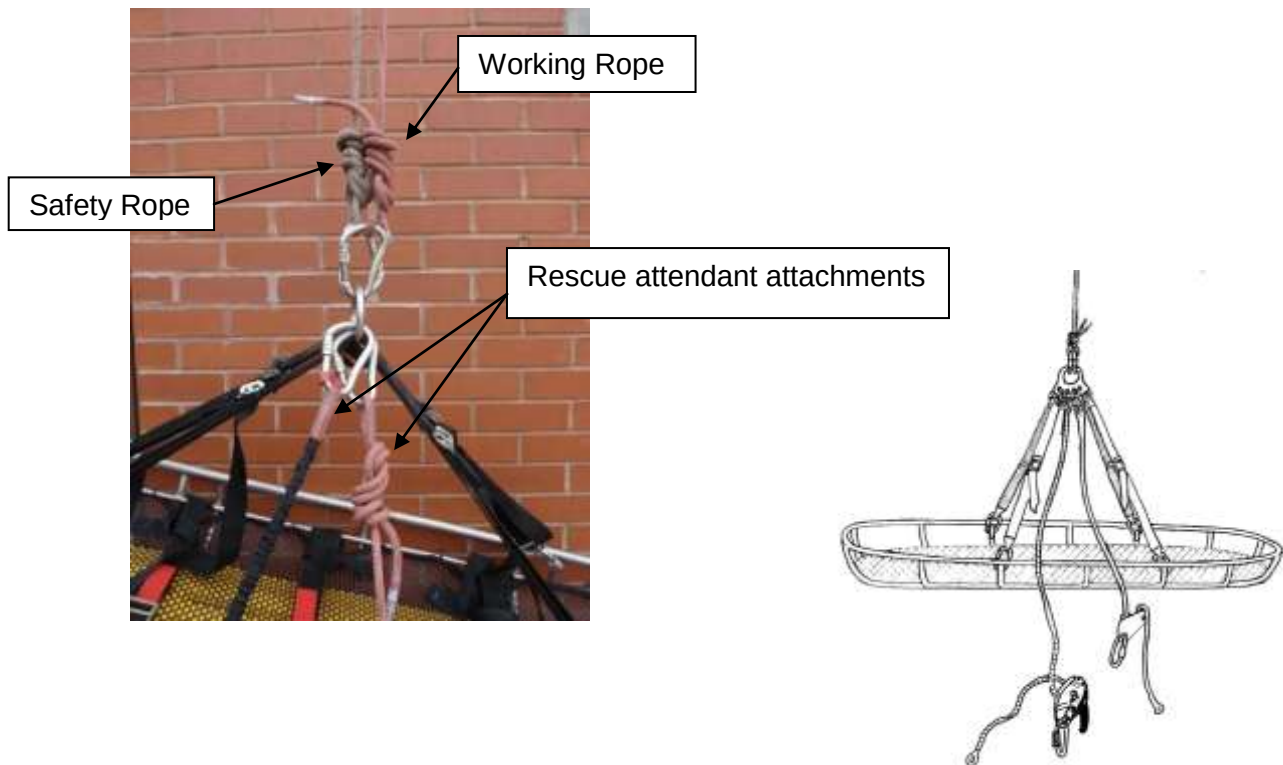
9:1



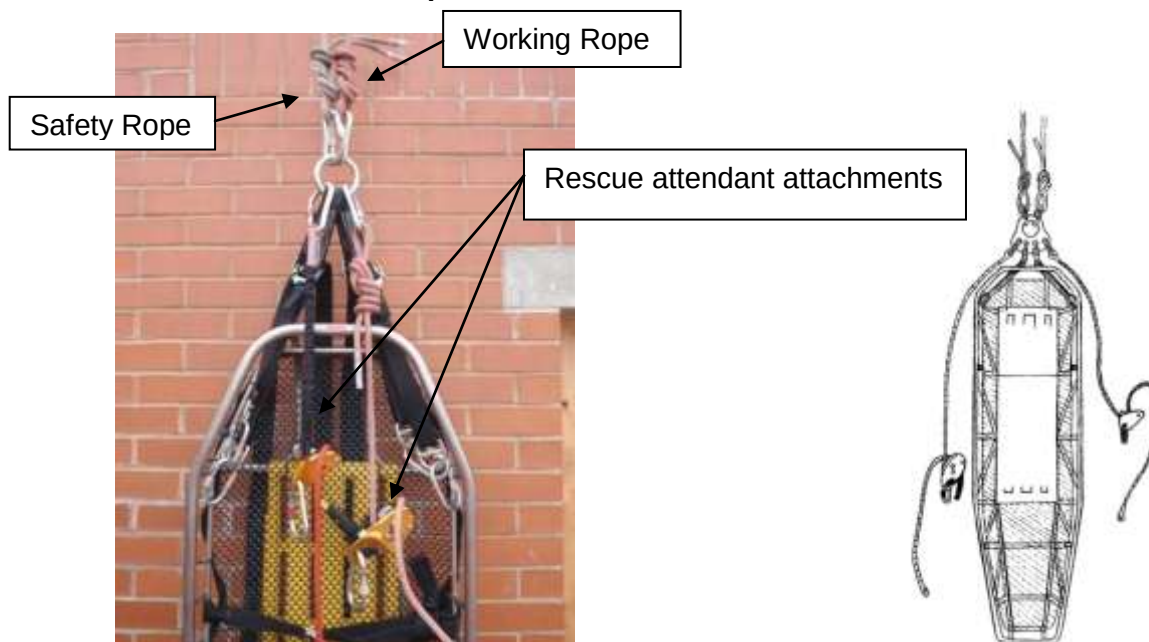
Stretchers

With all stretcher rigging consideration should be given to optimal mechanical advantage (i.e. V – Rig) to aid rescue load recovery.

Horizontal stretcher set up

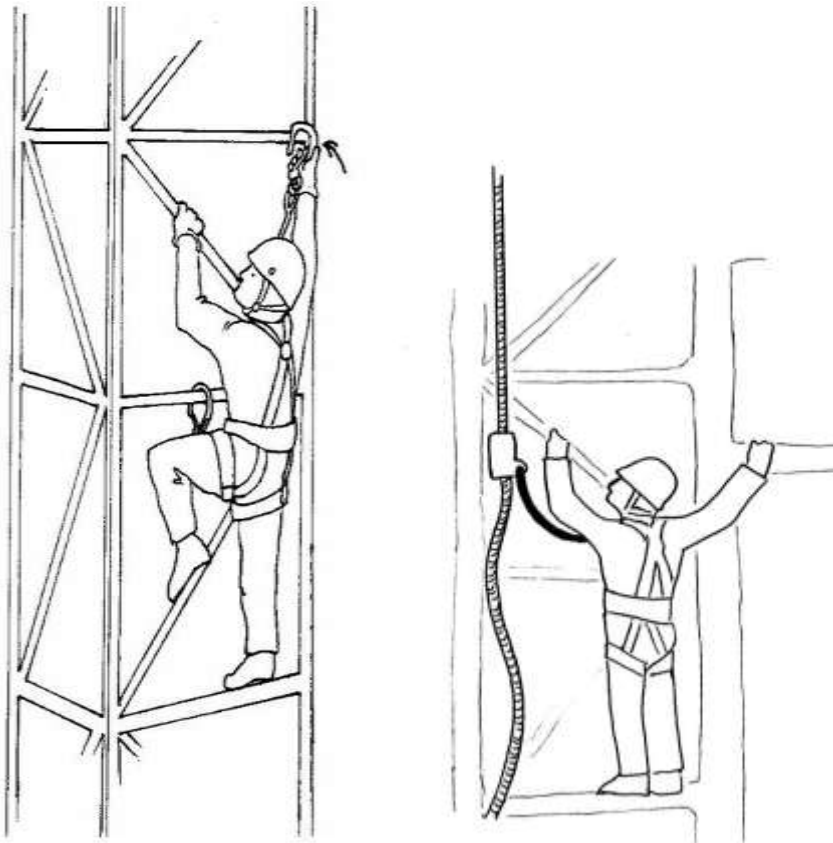


Vertical stretcher set up



Climbing High Structures

If only one person is required to climb a structure, the use of the twin tailed shock-absorbing lanyard is the method to be used.



Further rescuers can follow more rapidly if the lead climbers trail and then fix ropes. Subsequent climbers ascend using the fixed lines in conjunction with rope locks. They could also be safeguarded using a top rope safety.

Glossary

Critical point examination - The critical point examination involves ensuring that all points are backed up by other system components in such a way that no one point (either equipment or personnel) would cause a serious or fatal accident if it were to fail.

Focal Point - The point where an anchor system terminates and the working part of a rig begins is called the **Focal Point**

Anchor - An anchor can be defined as a safe point or object to which a load may be securely attached.

An anchor system includes the anchor **and** the equipment used to connect it to the load or the rope supporting the load.

100% Redundancy - Whenever possible it is advisable to build 100% redundancy into a rope system. This means that: -

Any component part within a system is backed up by another.

This doubling up considerably increases the margin of safety. Potential flaws in a system will always be twofold:

- There will always be a possibility of faults within the mechanics of the system.
- There is also the threat of human error, particularly in situations where people are working under pressure and in adverse conditions.

Clearance Distance

Distance required to fully deploy a fall arrest system safely.

(Lanyard length + energy absorption length + distance from attachment to feet + stopping distance)

Fall Factor

Fall factors are used to identify the potential seriousness of a fall, for the person taking the fall and the equipment and anchors that arrest the fall. It is effectively a ratio between the length of the fall and the length of the rope available to absorb the impact force created by its arrest.

$$\text{Fall factor} = \frac{\text{Length of fall}}{\text{Length of rope available}}$$

Notes